

### **REMARKS**

Claims 1-24, 26-30, 32-45, and 48-49 are pending. Claims 20-23, and 27 have been amended herein, for clarification. New claim 49 has been added. Support for the subject matter of the new claim is provided in the specification, for example, on page 5, lines 24-26. Claim 31 and withdrawn claim 47 have been canceled, without admission. It is believed that no new matter has been entered.

#### **Claim Rejection under 35 U.S.C. § 112**

In the present office action, the Examiner issued three §112 rejections. First, claims 1-24, 26-45, and 48 were rejected under 35 U.S.C. §112, first paragraph for failing to comply with the enablement requirement. Second, claims 1-24, 26-45 and 48 were rejected under 35 U.S.C. §112, first paragraph, for failing to particularly point out and distinctly claim the subject matter which applicant regards as his invention. Third, claim 9 was rejected under 35 U.S.C. §112, second paragraph, for lack of antecedent basis. These rejections are respectfully traversed.

Independent claim 1 recites a relative humidity of a humidified reactant output exceeding about 150%, and independent claim 27 recites a relative humidity of a humidified reactant output between about 100% and about 150%. The first two rejections are based on the Examiner's contention that output streams having above 100% relative humidity are supersaturated streams, which are unstable and inoperable in fuel cells.

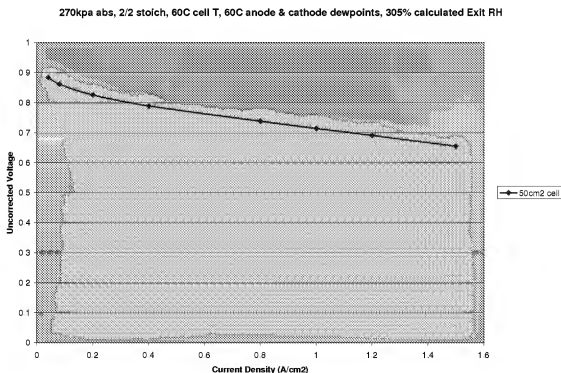
The Applicant respectfully refutes these assertions. In accordance with the present invention, the applicant respectfully has provided experimental data, which shows that outputs with relative humidity values above 100% (i.e. supersaturated) are possible for the presently claimed device. In the inputs (listed in the yellow box), the temperature of the fuel cell as well as the temperature of the anode and cathode dewpoints are at 60°C. Thus, the inlet gas streams enter the fuel at saturated conditions i.e. 100% RH. As shown in the mole fractions, the fuel cell produces water as the gas is being consumed along the flow channel, thus the water percentage has increased from inlet to outlet in the fuel cell. When considering that the inlet streams were fully saturated to 100% RH, increasing the water content would necessarily raise the relative humidity of the exit stream to above 100% RH at the outlet. In the experimental data, the RH at the exit or outlet is readily calculated (using stoichiometry, pressure, etc) to be 306.8%.

Inputs									
Press	T_cell	T_an	T_cath	an_eff	cath_eff				
kPa	C	C	C	-	-				
270	60	60	60	1	1				
st_H2	st_O2	y_CO2_dry	y_N2_dry						
-	-	-	-						
2	2	0	0.79						
Results				Possible cell averages					
RH_exit	Lambda	Conductivity	Mem res	Method	RH_avg	Lambda	Conductivity	Mem res	
-	-	S/cm	ohm-cm2	-	-	-	S/cm	ohm-cm2	
3.068	9.20	0.064	0.039	1	2.034	74.723	0.556	0.004	
				2	2.034	74.723	0.556	0.004	
				3	2.015	72.465	0.539	0.005	
				4	0.643	4.379	0.028	0.009	
Intermediate values									
Psat	TK	RH_an	RH_cath	RH_in2	RH_in3	RH_AVG			
kPa	K	-	-	-	-	-			
19.91	333.15	1.00	1.00	1.00	0.962	0.643			
Watfluxp		Lam_an	Lam_cath	Lam_in2	Lam_in3	Lam_avg4			
-	-	-	-	-	-	-			
-0.067		9.200	9.200	9.200	9.2	4.600			
watfluxp < 0 => water moves from anode to cathode									
Mole fractions									
Species	Inlet fuel	Inlet air	Outlet fuel	Outlet air					
H2	0.926	-	0.774	-					
CO2	0.000	-	0.000	-					
H2O	0.074	0.074	0.226	0.226					
O2	-	0.195	-	0.091					
N2	-	0.732	-	0.683					
Sum	1	1	1	1					

As the Examiner asserts, supersaturated conditions may raise the possibility of fuel cell flooding. The Applicant has recognized this problem and developed the present claimed device to prevent flooding and ensure operability at supersaturated conditions. As disclosed in the specification on pages 6 and 7, various parameters, e.g., surface area, porosity, pore size, etc, of the diffusion media substrate and mesoporous layer may be adjusted, alone or in combination, to achieve operability at humidity values above and below 100% RH. For example, including a larger percentage of micropores with the high surface area carbons make it more difficult to wick water away from the membrane electrode assembly, but also make the diffusion media better suited for operation under low humidity. (Page 7) For similar reasons, carbonaceous components of relatively larger particle sizes are better suited than smaller particle sizes under high

operational humidity. (Page 7). Consequently, the application sufficiently enables one of ordinary skill to operate a device, e.g., a fuel cell, wherein the humidified reactant output includes a relative humidity above 100% RH (supersaturated).

To further demonstrate that the present claims enable fuel cell use at supersaturated conditions (i.e. above 100% RH), the Applicant has provided a polarization curve plotting current density against voltage for an embodiment of the present invention. In this example, the fuel cell has a humidified reactant outlet of 305% RH; yet, the fuel cell is still operable.<sup>1</sup> When a fuel cell is flooded, the water accumulation restricts transport of reactant molecules to catalyst sites on the membrane electrode assembly.<sup>2</sup> With no reaction, the voltage potential greatly decreases. This is not the case here.



Consequently, the present specification enables one of skill in the art to make or use a device which is operable at supersaturated conditions, i.e. above 100% RH. Accordingly, the claims do not fail for enablement under §112 ¶1 or for indefiniteness under §112 ¶2.

<sup>1</sup> Fuel cells become in operable when voltage is at or near zero. For more discussion, please see e.g. Trabold et al, *In situ investigation of water transport in an operating PEM fuel cell using neutron radiography*, International Journal of Heat and Mass Transfer 49 (2006) 4719, 4712-4720.

<sup>2</sup> *Id.*

Regarding the Examiner's third §112 rejection, the Examiner asserted that "said hydrophobic component", as recited in Claim 9, lacks antecedent basis in claim 1. Applicants respectfully refute Examiner's assertion by highlighting the following element of claim 1:

said mesoporous layer is carried along at least a portion of one of said first and second major faces of said substrate and comprises a hydrophilic carbonaceous component and a *hydrophobic component*;

Consequently, claim 9's recitation of "said hydrophobic component" has sufficient antecedent basis in claim 1; therefore, the rejection under §112 is believed to be overcome and reconsideration is respectfully requested.

#### Claim Rejections under 35 U.S.C. § 103

Claims 1-3, 5, 9-11, 13, 15, 17, 20-24, 27-30, 33, and 48 were rejected under § 103 as being unpatentable over Barton (US 2003/0157397) in view Yoshida (US 2003/0091891). Claims 14, 18, 19, 32, and 34 were rejected under § 103 as being unpatentable over Barton in view Yoshida and further in view of Cipollini (US 6,379,827). Claims 4 and 6 were rejected under § 103 as being unpatentable over Barton in view Yoshida and further in view of Larson (US 2003/0134178). These rejections are respectfully traversed.

To establish a prima facie case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. *See* MPEP 2143. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Independent claims 1, 27, and 36 recite devices configured to convert a hydrogenous fuel source to electrical energy, wherein the devices comprise a first reactant input, a second reactant input, a humidified reactant output having a relative humidity of a humidified reactant output exceeding about 150% (claim 1), between (100 and 150% (claim 27), or below 100% (claim 36). The diffusion media comprises a diffusion media substrate and a mesoporous layer. The diffusion media substrate comprises a carbonaceous porous fibrous matrix defining first and

second major faces, and the mesoporous layer is carried along at least a portion of one of the first and second major faces of the substrate and comprises a hydrophilic carbonaceous component and a hydrophobic component. The hydrophilic carbonaceous component comprises a surface area of below about  $85 \text{ m}^2/\text{g}$  (claim 1), between about  $200 \text{ m}^2/\text{g}$  and  $300 \text{ m}^2/\text{g}$  (claim 27), or above about  $750 \text{ m}^2/\text{g}$  (claim 36). The hydrophilic carbonaceous component also comprises a mean particle size of between about 35 nm and about 70 nm (claim 1), between about 15 nm and 40 nm (claim 27), or less than about 20 nm (claim 36). None of the references, either singularly or in combination, teach or suggest all elements of claims 1, 27, and 36.

### Claim 1

As the Examiner acknowledges, the cited references are silent as to the relative humidity of the humidified reactant output streams as recited in claim 1. Andrews, the reference cited for teaching this claim element, discloses that its humidified reactant gas stream is maintained at a *setpoint temperature above the dew point temperature* of the humidified reactant gas; consequently Andrews does not teach that its humidified reactant output or its input are saturated, let alone supersaturated. *See* [0024] Regardless of the teaching deficiency, the Examiner modifies the Andrews (the reference cited for this claim element) through impermissible hindsight in order to teach relative humidity of above 150% RH for a humidified reactant output as recited in claim 1. In furtherance of her hindsight reconstruction, the Examiner made the following assertion:

The Examiner notes that since relative humidity above 100% is an unstable state, Andrew's apparatus is capable of achieving supersaturated state when the apparatus makes a transition from a normal operating state to subnormal operating state, the reactant gas requires time to adjust to the subnormal state. At that instant, the reactant gas will be supersaturated before adjusting to the 100% saturation state of the subnormal state.

Examiner is reminded that "the mere fact that prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. It is impermissible to use the claimed invention as an instruction manual or "template" to piece together the teachings of the prior art so that the claimed invention is rendered obvious." *In re Fritch*, 23 USPQ2d 1780, 1783-4 (Fed. Cir. 1991). Here, the current

application is the only reference that teaches the relative humidity of the output streams, and is also the only reference that teaches devices, e.g. fuel cells, which are operable at supersaturated conditions. The Examiner's modification of the Andrews apparatus constitutes impermissible hindsight reconstruction, and is therefore an improper basis for a rejection under §103.

Moreover, none of the references, either singularly or in combination, teach or suggest a mesoporous layer with a hydrophilic carbonaceous component characterized by a surface area of below about  $85 \text{ m}^2/\text{g}$  and a mean particle size of between about 35 nm and about 70 nm. Barton, which is cited for teaching this claim element, discloses a surface area of about 50 to about  $800 \text{ m}^2/\text{g}$ ; however, Barton provides no guidance that would lead to one of ordinary skill in the art to configure the surface area to below  $85 \text{ m}^2/\text{g}$  as recited in claim 1. Barton is silent as to particle size. Noting this deficiency, the Examiner cites Yoshida, which discloses a mean or average particle size of 30nm; however, Yoshida does not teach a mean particle size of about 35 nm to about 70 nm as recited in claim 1. As result, none of the references, either singularly or in combination, teach or suggest all elements of claim 1.

#### Claim 27

For the reasons provided in the arguments regarding claim 1, none of the references teach or suggest the relative humidity of between about 100% to about 150% for a humidified reactant output exiting the device as recited in claim 1. Furthermore, none of the references teach or suggest a mesoporous layer with a hydrophilic carbonaceous component having a surface area of between about  $200 \text{ m}^2/\text{g}$  and about  $300 \text{ m}^2/\text{g}$  and a mean particle size of between about 15 nm and about 40 nm as claimed. As stated above, Barton discloses a surface area of about 50 to about  $800 \text{ m}^2/\text{g}$ ; however, Barton provides no guidance that would lead to one of ordinary skill in the art to configure the surface area to between about  $200 \text{ m}^2/\text{g}$  and about  $300 \text{ m}^2/\text{g}$  as recited in claim 1.

Moreover, as the Examiner acknowledges, Barton fails to teach that the mesoporous layer infiltrates into the diffusion media substrate to a depth of up to  $10 \text{ }\mu\text{m}$  as recited in claim 27. Noting this deficiency, the Examiner states that the carbon paper is porous, and thus must necessary infiltrate the adjacent microporous layer at a microscopic level. However, Barton is provides no teaching regarding infiltration of the carbon paper into the microporous layer, much less infiltration up to  $10 \text{ }\mu\text{m}$ . The only reference which teaches infiltration is the present

application, which Examiner is barred from using to bridge the teaching gap. Yoshida, and the additional cited references, Cipollini, and Larson, do not cure the above noted deficiencies of Barton, thus the references, either singularly or in combination, fail to teach or suggest all elements of the claim 27.

#### Claim 36

Similar to claims 1 and 27, the cited references are silent as to the relative humidity of the humidified reactant output from the device as recited in claim 36. Additionally, none of the references, either singularly or in combination, teach or suggest a mesoporous layer having a hydrophilic carbonaceous component with a surface area of above about  $750 \text{ m}^2/\text{g}$  and a mean particle size of less than 20 nm. As stated above, Barton discloses a surface area of about 50 to about  $800 \text{ m}^2/\text{g}$ ; however, Barton provides no guidance that would lead to one of ordinary skill in the art to configure the surface area to above about  $750 \text{ m}^2/\text{g}$  as recited in claim 36. Barton is silent as to particle size, and Yoshida fails to cure this teaching deficiency of Barton. Yoshida teaches a mean or average particle size of 30nm, not a mean particle size of less than about 20 nm as recited in claim 36. As result, none of the references, either singularly or in combination, teach or suggest all elements of claim 36. Accordingly, the rejections under §103 are believed to be overcome, and reconsideration is respectfully requested

#### Conclusion

The Applicants respectfully submit that, in view of the above amendments, and remarks, the application is now in condition for allowance. The Examiner is encouraged to contact the undersigned to resolve efficiently any formal matters or to discuss any aspects of the application or of this response. Otherwise, early notification of allowable subject matter is respectfully requested.

Respectfully submitted,

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